# A METHOD AND APPARATUS FOR READING AND CONTROLLING UTILITY CONSUMPTION

This application is a continuation-in-part of prior Application No. 09/896,159, filed June 28, 2001, the entire contents of which are hereby incorporated by reference.

## FIELD OF THE INVENTION

This invention relates generally to a utility usage control system, and more particularly to a means of obtaining real-time utility consumption readings and also managing utility consumption by signaling for the control of end-use devices from a computer or personal digital assistant (PDA).

## BACKGROUND OF THE INVENTION

There are various types of automatic meter reading devices (AMR) which use optical light-sensing arrangements to provide remote utility readings for determining utility consumption and for billing purposes. These devices were typically developed as a cost-effective alternative to the existing meter reading methods and devices. For example, these AMR devices avoid having a person walk or drive from establishment to establishment and manually read each meter. However, the majority of methods using optical light-sensing devices are installed inside the existing meter and/or require professional installation. Thus, a skilled or trained individual must physically remove the glass housing present on such meter in order to install the automatic reading device. This process is inefficient and also very costly for either the utility company or the consumer.

In U.S. Pat. No. 5,767,790, the device utilizes a photoelectric sensor for reading the watt-hour indicator of electricity service usage. A light source beams a light on a rotating disk in the meter. The disk reflects the light except for one darkened area, which absorbs the beam of light. The reflected light is sensed by the photoelectric sensor and a pulse is sent each time the reflected light is not sensed. Each pulse indicates one full rotation of the disk. All of the computing elements of the monitor system are contained within the utility watt-hour meter housing, and even the glass cover is replaced with a polycarbonate cover. Other similar devices installed within the existing meter housing are disclosed in U.S. Pat. No. 4,327,362 and U.S. Pat. No. 5,506,404. A significant

disadvantage typical of these devices is that the installation process requires the existing meter to be physically opened and/or the optical light sensing arrangement to be assembled with professional assistance. Thus, an ordinary consumer generally cannot set up the device, and therefore consumers would have to bear installation costs.

In U.S. Patent No. 5,559,894, a camera is used to read the indicia of a plurality of dials. This automatic meter reader device is integrated into a substantial housing structure and requires a substantial effort to install. This device uses Optical Character Recognition (OCR) to read the serial number of the meter but does not specify such OCR use to read utility consumption data. In addition, this method and device requires alignment and perhaps continuous realignment in order to accomplish its task, thus rendering it costly to use and costly to maintain.

In U.S. Pat No. 5,880,464, infrared light sensors are used to detect the shadow of a meter pointer against a meter face to enable the meter reader to determine consumption rates. This automatic meter reader device is placed on the cover of the watt-hour meter. However, the device requires the angle and heights of the light source and sensor to be adjusted in a specific manner using a height adjustment carrier having a collar that must be tightened, which a typical customer most likely would find difficult to accurately adjust. Furthermore, no provision is made for powering the device and thus further installation problems may be created for the consumer.

There are also certain utility-based applications in which a network controller or some other headend device located in a utility company interrogates the automatic meter reading device, in order to find out the utility usage for billing purposes. Typical drawbacks that are inherent in these systems are that customers cannot see their use in real-time, cannot access this information except when a billing statement is received and, cannot see data except in the standard format chosen by the utility company.

In addition, there are various types of readers that can be utilized to manage the consumption of electrical power or fossil fuels. U.S. Pat. No. 6,167,389 allows the consumer, through the use of adapted end-use devices, to program these devices based on a pricing-tier billing system. The pricing-tier billing system sets a billing rate for power consumption based on the load levels on a power grid. A utility company may use a billing system with four-tiers: Normal Load, Medium Load, High Load, and Critical

Load. Each tier has a different billing rate for power consumption with the Critical Load tier charging at the highest rate. The utility company may transmit data packets though an open network from a centralized headend to gateways at customer locations. These data packet cause the gateways to generate random startup time offsets, to control when end-use devices will be started. This is useful to protect the power grid from being loaded such that it results in a blackout. However, this system does little to provide feedback to the consumer, let alone provide them with real-time data on their use and cost that allows the consumer to directly shed load voluntarily or with incentive, in order to help the utility balance its load demands. Further, it requires either a full start or stop operation of equipment rather than a gradual increase or decrease of individual loads. Thus, this device is primarily aimed at providing grid-level control to a utility but does little to help a consumer manage their consumption in a gradual and comfortable manner.

## SUMMARY OF THE INVENTION

The present invention provides an electro-optical, automatic meter reader (AMR) for enabling a consumer to view and manage utility-based consumption on a computer, which may be any form of microprocessor-based computer or PDA. Such utility based product being consumed may be electrical power, natural gas, water or other products and services. The automatic meter reader is an apparatus for optically reading a meter using a sensor that can be used to monitor electricity consumption. A sensor of the apparatus may be attached to a bracket, which may be mounted to the outside cover of the meter. An installation process of the apparatus need not require modification of the existing meter nor require removal of the housing of the existing meter. An end-user may install the automatic meter reader without special skills or tools, in fact, with no additional hardware other than those included as a part of the system.

The photoelectric sensor beams a light onto a rotating disk, visible on the face of the meter, whose surface reflects the light. A marker such as a black dot or line placed on the rotating disk absorbs the beamed light resulting in an interval where a lower level of light is being reflected. The photoelectric sensor counts these intervals, representing the number of turns the disk rotates indicating utility usage during a given time period. The apparatus connects to a data-collection unit through an Input/Output (I/O) port. The data-collection unit stores the data from the sensor. The I/O port connection may also serve to

supply power for the apparatus through one otherwise unused pin of that serial connector being assigned as a power carrier, thus avoiding the need for a dedicated power supply. The data collection unit may also be used to store data when the computer is turned off and can be powered by an external 12 volt DC power supply.

Alternatively, if the meter includes a digital or seven-segment display, the automatic meter reader may monitor the value displayed by the meter by monitoring the state of each segment or, a subset of those segments associated with the display.

The data-collection unit connects through a second I/O port, to the computer. The computer provides the consumer and utility with the ability to either directly or remotely view and manage his consumption. The computer collects the data and provides information relating to utility-based consumption such as real-time rate of usage and historical usage levels. For example, information is arranged in three graphs that are analogous to information common to automobile travel. These include the real-time rate-of-use, comparable to the speedometer of an automobile. This graph tells the user their consumption rate on an instantaneous basis at the present moment. The second graph, a time-segment-based graph for displaying quantity vs. time data, is comparable to the trip odometer. This graph shows the user their consumption on a day-to-date, daily, month-to-date, or other calendar-based time basis. It may also display utility or other time-based segments such as peak period, summer, Mondays, etc. The final graph is comparable to the general odometer. It shows the total energy consumption through the life of the system. Each graph can be displayed in units of measurement of the appropriate utility. For example, kilowatt hours for electric utilities, therms for natural gas utilities and gallons for water utilities. In addition, each graph may provide an alternate display in dollars or other forms of currency. By presenting this data in three logical and understandable formats, Data can be used to forecast whether the consumer will be under his specified usage or cost level of consumption. Such forecasts are commonly used by trip computers in automobiles to tell the consumer whether they should adjust their speed to reduce fuel consumption, when they will arrive at their destination based upon present and average speed, and how many miles they have to go to complete their trip.

In the present invention, if the forecast indicates that the present usage rate will cause that consumer to exceed the baseline unit or cost level, a signal is sent from the

computer to enable the manual or automatic control of usage of devices to assure that they end the time segment below the specified requirement, especially during energy or water crisis situations. A forecast rate for use is shown for the consumer as a red colored line on each graph. A second line, the rate of consumption that must be averaged in order to arrive at or under the base line, is also displayed on each graph. If a consumer is averaging under their baseline amount, for the period in question, the bar for that particular graph shall show as a green bar. If the consumer is averaging over the baseline amount for the period in question, the bar for that particular graph shall show as a red bar. For example, if the consumer is averaging a rate of consumption use on a daily basis that will exceed the monthly baseline level if continued for the rest of the cycle, the monthly bar shall show as red. If the consumer is averaging a rate of consumption on an hourly basis that will exceed the average daily baseline, that day's bar shall show as red in color. If the consumer is averaging a rate of consumption on a peak-period basis that will exceed the average baseline, that segment's bar shall show as red in color. In this way the consumer is always aware of their status to achieve baseline levels for the hour, day, and month or any time segment used by a utility or chosen by the consumer.

Further, the consumer or utility may program the computer to automatically control the rate of utility-based consumption. A number of commonly available products accept control commands including thermostats, lighting, dimmers, appliances, valves and other items. Thus, the computer may alert such devices through automatic commands to, for example, adjust the thermostat on an air conditioning unit in response to the forecast. In addition, a communication system, such as the Internet, can also be utilized to allow the computer to communicate to the utility company for usage, control and billing purposes or to allow both the consumer and utility to access and manage consumption from a remote computer or PDA.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more detail with reference to preferred embodiments of the invention, given only by way of example and illustrated in the accompanying drawings in which:

FIG. **1** illustrates a block schematic diagram of an apparatus for reading and managing power consumption in accordance with the present invention;

FIG. **2A** provides an illustrated embodiment of the reader in a plan view;

FIG. **2B** provides an illustrated embodiment of the reader in a side sectional view;

FIG. **3A** depict the bracket attached to a conventional meter in a front view;

FIG. **3B** depict the bracket attached to a conventional meter in a side view;

FIG. **4** is an illustration of a preferred sensor;

FIG. **5A** provides an illustration of a conventional utility meter with a digital display;

FIG. 5B provides an illustration of a conventional utility meter with dial indicators;

FIG. 5C is an illustration of a digital display that may be found in the meter of FIG. 5A;

FIG. 5D is an illustration of an individual seven-segment numeric indicator;

FIG. 5E is an illustration of a one embodiment of a sensor, which may be used to detect the value of the seven-segment indicator;

FIG. 5F is an illustration of one embodiment of a fiber optic sensor and the digital indicator;

FIG. **6** illustrates a user interface displayed on the screen of the computer;

FIG. **7** is an illustration of the computer connected to power consuming device through a serial port or Ethernet interface of the computer;

FIG. **8** provides an illustration of the computer connected to a communication system for remote access to the data stored and compiled on the computer; and

FIG. **9** illustrates an alternative embodiment of the present invention using wireless communication to transmit the data obtained by the reader.

## DETAILED DESCRIPTION

FIG. **1** illustrates a block schematic diagram of an apparatus **100** for reading and managing power consumption in accordance with the present invention. As shown in FIG. **1**, a reader **104** is attached to a typical utility meter **102** such as an analog or digital power meter commonly found on homes, apartment buildings and commercial buildings. The reader **104** provides a means for automatically reading power consumption and may eliminate the need for manually reading the meter **102**. The data generated by the reader

**104** may be continuously transferred through a connection such as a serial cable **120**, to a data collection unit **106** or alternatively directly to the monitoring device **110**, such as a computer.

The data collector **106** is therefore optional. When provided, the data collection unit stores data generated by the reader **104**. The data collection unit **106** may store data for a limited time when the monitoring device (computer) **110** is shut off or in the event of a power failure. With appropriate memory, the unit **106** may be able to store data for up to a year. The preferred embodiment of the data-collection unit **106** for a household may include a single serial port interface from the reader **104**, such as a RJ-11 or RJ-45 and a single serial port out, to the computer **110**, such as a DB-9. The preferred data-collection unit **106** is approximately 2" wide and 3"long and includes a 12 volt input, such as from a wall mounted AC to DC converter **108**. A battery, such as a standard watch battery, may be provided for backup. Further, the data collection unit **106** may be powered by the serial driver of one pin on the serial port of the computer. The preferred data-collection unit **106** includes a microprocessor such as a PIK Microprocessor including non-volatile memory and a timer crystal. It will be apparent that any microprocessor or controller could be used.

In a preferred application of the invention where multiple power meters are monitored, such as an apartment building or a commercial building, may be similar to the household application described above. However, the data collection unit **106** may be provided with inputs for additional readers **104**, such as four to eight inputs and an optional Ethernet connector for networking to a single monitoring device **110**.

The preferred embodiment of the monitoring device **110** may be a conventional general-purpose computer system or a serial server containing one or more serial ports and an Ethernet port, and need not be specific to this application. The monitoring device **110** receives the data from a cable **118,** such a serial cable, which connects directly to the reader **104**. Alternatively, a cable **116** may be a serial cable connecting to the optional data-collection unit **106** through a serial port in, such as a RJ-45 or RJ-11 connector and a serial port out, such as a DB-9 connector. The monitoring device **110** will not lose information during power failure as it stored its data in non-volatile memory and real-time data is only gathered when power is present and being consumed. In addition, when

employed, the data collector **106** will not lose its data during an outage because it holds historic values in non-volatile memory and real-time data is only gathered when power is present and, thus, being consumed.

The monitoring device **110** may be connected to a communication system **112** or network, such as the Internet to allow remote access **114** of the data. For example, a utility company may obtain the data for billing purposes or by the end-user who wants to control his power consumption from his PDA or computer from a remote location, such as his office.

FIGS. **2A** and **2B** provides an illustrated embodiment of the reader **104** in both a plan view (FIG. **2A**) and a side sectional view (FIG. **2B**). The reader **104** includes a bracket **202** and a sensor **210** such as a photoelectric sensor. The bracket **202** preferably is a unitary body and lacks movable parts thus being relatively cost effective and also being easy to install. The preferred material for the bracket **202** is either rubber or plastic but it may be made out of any suitable material. Included in the bracket **202** may be an aperture **208** for accepting the sensor **210**. The sensor **210** may be threaded into a nut **216** attached to the meter **102**. For example, the nut **216** may be plastic and secured using glue or epoxy to the meter face. The nut **216** may fit into a recessed portion **218** of the bracket **202**. In addition, a heat and moisture dissipation channel **212** may be included to allow ventilation of the heat generated by the sensor **210**. The heat generated from the sensor **210** may be used to melt ice in cold-weather climates in which case melted ice may escape through the channel **212**. In addition, the channel **212** acts as a temperature equalization path between the sensor **210** and the outside elements, thus preventing the fogging of the lens in the sensor aperture **406**. The bracket **202** may also incorporate a fastener **204** and **206**, for example a hook and loop such as Velcro or double-sided tape or other adhesive to attach to the meter **102**. As illustrated in FIG. **2B**, the back of the bracket **202** may follow the same contour as the meter **102** to ensure proper alignment and secure mounting to the meter.

FIGS. **3A** and **3B** depict the bracket **202** attached to a conventional meter **102** in both a front view (FIG. **3A**) and also a side view (FIG. **3B**). The bracket **202** may attach to the translucent (typically glass), outside cover **306** of the meter **102** conventional to most existing electric utility meters. As mentioned above, the shape **214** of the bracket

**202** may follow the same contour as the translucent outside cover **306** of the existing meter **102** ensuring proper alignment with the existing meter **102**. An installation process of the bracket **202** to the translucent outside cover **306** of the existing meter **102** need not require modification of the existing meter **102** nor removal of the translucent outside cover **306**. Furthermore, the installation may only require one part of the bracket **202** to be rigidly attached to the translucent outside cover **306** allowing an end-user to install the reader **102** without special skills or tools.

FIG. **4** is an illustration of a preferred sensor. The reader **104**, in a preferred embodiment, utilizes a photoelectric sensor **210** such as the Mini-Beam 2 from the Banner Engineering Corp. of Minneapolis, MN to read the existing meter. The sensor **210** includes a light source and a photo receptive element. The preferred size of the sensor **210** is about a 1" square but is not limited to that size. The preferred sensor also includes a threaded member **406** which may be screwed into a nut **216** secured to the meter housing **306** as mentioned above. The nut **218** may also secure the sensor **210** to the bracket **202** as shown in FIG. **2B**. For example, the nut **216** may fit into a recessed portion **218** of the bracket **202**. A light emitting diode (LED) **402** may be placed on the back of the sensor **210** to provide a visual indication that the sensor **210** is picking up the correct signal such as to aid in installation of the reader **104**. The sensor **210** may incorporate a cable **404**, such as a serial cable, that supplies the power preferably with 10V or 12 V but may range from 10 – 30V. The cable **404** may also provide the means for transferring data.

FIGS. **5A** and **5B** provide an illustration of conventional utility meters **102** such as a digital meter **506** and an analog meter **508**. The digital meter **506** may include a numeric display **510**. The sensor **210** (FIG. **4**) is oriented to beam a light, such as a visible red 660 nm, or another wavelength, onto a rotating disk **502** located in the meter **102**. The beam of light passes through the translucent outside cover **306** of the meter **102**. The surface of the disk **502** reflects the light; the reflected light is sensed by the photo receptive element of the sensor **210**. A marker **504**, such as a darkened area, normally found on the rotating disk **502** absorbs the beamed light resulting in an interval where a lower level of light is being reflected to the sensor **210**. The number of intervals, counted by the sensor **210**, represents the number of turns the disk rotates indicating

utility usage during a given time period. The time between each interval is inversely proportional to the rate of power consumed. Further, the aforementioned LED **402** may turn on to indicate whether the sensor **210** has made contact with the rotating disk **502** and turn off when the black marker **504** is being sensed, thus a consumer with no special skills, will be sure of the proper alignment of the sensor **210.**

The reader **104** may use software algorithms to avoid spurious data in which light sensors are vulnerable to such as may be caused by sunlight striking the rotating disk **502**. The rotating disk **502** in a meter **102**, may have a maximum number of rotations per second and the reader **104** may be programmed to ignore certain detections. For example, if a sensor detects more then 2 passes per second from a rotating disk **502** with a 2 rotations per second maximum, the reader **104** may be programmed to ignore the second pass. The reader **104** also may have the capability to alert the end user that an adjustment may need to be made to the sensor **210**.

The reader **210** may also use a software algorithm that avoids spurious data based on the time interval between each pass. For example, if a long-short-long pattern of the intervals between passes is sensed by the reader **210** may be programmed to ignore the middle short reading. Again, an alert signal may be sent to the end user that an adjustment may need to be made to the sensor **210**.

FIG. **5C** is an illustration of the numeric display **510** that may be included as a part of the digital meter **506**. The numeric display **510** may be arranged as an array of plural seven-segment numeric indicators **512**. FIG. **5D** is an illustration of one seven-segment indicator **512**, which may be comprised of: a top segment **514**, a top-right segment **516**, a center segment **518**, a bottom-right segment **520**, a bottom segment **522**, a bottom-left segment **524** and a top-left segment **526**. Segments **514** thru **526** may be used to indicate a number zero thru nine.

FIG. **5E** illustrates a sensor assembly **528** that may be used to determine the value of the indicator **512**. The sensor assembly **528** may be comprised of: a top sensor **530**, an optional top-right sensor **532**, a center sensor **534**, an optional bottom-right sensor **536**, an optional bottom sensor **538**, an optional bottom-left sensor **540** and an optional top-left sensor **540**. Sensor **530** may be used to determine the state of the segment **514**. The sensor **532** may be used to determine the state of the segment **516**. The sensor **534** may

be used to determine the state of the segment **518**. The sensor **536** may be used to determine the state of the segment **520**. The sensor **538** may be used to determine the state of the segment **522**. The sensor **540** may be used to determine the state of the segment **524**. The sensor **542** may be used to determine the state of the segment **526**. An array of sensor assemblies **528** may be arranged in front of an array of indicators **512**, such as numeric display **510**. Sensor assembly **528** or an array of sensors **530** thru **538** may be held in place in front of an array of indicators **512** by an appropriate fixture **544**. For example, similarly to the embodiment of reader **104** in FIG. **2**, the fixture **544** may be formed as a unitary body that is affixed to the meter **102** (FIG. **5A**) by a hook and loop fastener, or other appropriate means.

Table 1 illustrates which segments **514** thru **526** and which sensors **530** thru **542** are associated with which value of indicator **512**. A first column of Table 1 lists sensors **530** thru **542**. A second column of Table 1 lists corresponding segments **514** thru **526**. A first row of Table 1 lists values that indicator **512** might display (i.e. 0-9). Each row between rows two thru nine is associated with one sensor and one segment. For example, row two is associated with sensor **530** and segment **514**. While, each column between columns three and twelve is associated with a value that indicator **512** can display. The state of segments **514** thru **526** and therefore the state of sensors **530** thru **542** is dependent on the value of indicator **512**. The Xs below each value of indicator **512** are indicative of the state of the segment that is in the same row as the X. For instance if value of indicator **512** is "1" than according to Table 1, segments **516** and **520** will be in a different state then segments **514, 518, 522, 524** and **526**.

Table 1

| | | Value of Indicator **512** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sensor | Segment | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **530** | **514** | X | | X | X | | X | | X | X | X |
| **532** | **516** | X | X | X | X | X | | | X | X | X |
| **534** | **518** | | | X | X | X | X | X | | X | X |
| **536** | **520** | X | X | | X | X | X | X | X | X | X |
| **538** | **522** | X | | X | X | | X | X | | X | |
| **540** | **524** | X | | X | | | | X | | X | |
| **542** | **526** | X | | | | X | X | X | | X | X |

In an alternate embodiment of the invention, a subset of five to six of the sensors of the set of seven sensors **530** thru **542** may be used to uniquely determine the value of the indicator **512**. Where a set of six sensors are used to determine the value of the indicator **512**, the set of six sensors may be comprised of sensors **530**, **534** and four sensors of a set comprising sensors **532**, **536**, **538**, **540**, and **542**. In other words, if only six sensors are used, then one of the sensors **532**, **536**, **538**, **540**, and **542** is optional. Where a set of the five sensors are used to determine the value of indicator **512**, the set of five sensors may be comprised of sensors **530**, **534**, **540**, **542** and one sensor of a set of the sensor **536** and the sensor **538**.

In another alternate embodiment of the invention, rather then providing one sensor per segment as in FIG. **5E**, an integrated array may be provided. For example, the array of sensor assemblies **528** may be replaced with a charged-coupled device (CCD). The CCD is an integrated two-dimensional array of sensors. Alternately the CCD may be replaced by four or five linear array detectors (LADs). If an integrated array such as a CCD or LAD is used, an optical character recognition (OCR) routine may be used to determine a value presented by digital display **510**. Each sensor in the CCD or LADs array is generally referred to as a pixel. One or more pixels in the array may be assigned to each segment in the digital display **510**. One or more lenses may be used to focus an image of digital display **510** onto the CCD or the LADs. The one or more lenses may be used to de-magnify an image of the digital display **510** so it will fit on to a small CCD.

The one or more lenses may have different magnifications in the horizontal and vertical directions. The one or more lenses may be Holographic Optical Elements (HOEs). The HOEs may be used for diffracting light reflected from or transmitted by the numeric display **510** onto a set of sensors such as a CCD, a LAD or an array of sensor assemblies **512**.

FIG. **5F** illustrates an alternate embodiment of the invention, in which a fiber optic sensor bundle **540** may be used to gather data. The fiber optic bundle **546** is comprised of a multiple fibers. The input face of each individual fiber may be positioned in front of each individual segment of digital display 510, such that one fiber or a group of fibers may be assigned one segment for which it gathers light to be used in determining the state of each segment. The output ends of the individual fibers may be bundled together to form one or more fiber optic bundles **546**. The output ends of the individual fibers may be coupled to one or more fiber optic amplifiers for converting the signal into usable data. An example of such a fiber optic sensor may be obtained from Keyence Corporation of America.

The sensor **210** may include a light source to illuminate the indicators included in the utility meter such as the digital display **510** or the rotating disk **506**. The light source may be pulsed to eliminate the effect of changes in the ambient light on the reading of indicators. The sensor **210** may be an infrared detector and if the light source is necessary, the light source may be an infrared light source.

In yet another embodiment, reader **104** may include an infrared camera. The infrared camera may have a short focal length and include a mount that allows the camera to be rotated 360 degrees about an axis such that the camera may be mounted on the meter and point at a display in the meter. An example of such a camera is the Bullet Camera, model CVC-325WPS sold by CSI/SPECO.

FIG. **6** illustrates a user interface displayed on the screen of the computer **110** (FIG. **1**). As Illustrated in FIG. **6**, the computer **110** may provide a central location for the end-user to remotely connect to or use directly to view the data collected by the reader **104**. Software stored in the computer **110** memory causes the computer **110** to compile data from the reader. The computer may be compliant to all automatic meter reading devices, and therefore might not be specific to the aforementioned reader **104**. In

addition, the computer may incorporate an adjustable architecture to optimize for various sizes and complexities fitting to the end-user's need.

An interface **602** such as web-based interface (e.g. a browser), allows the end-user to monitor the information relating to consumption. The interface **602** may, for example, render all graphic data as line or bar graphs **608** using Macromedia Corporation's Flash program. By choosing to render data via flash, the vast majority of the program overhead for rendering the interface **602** is handled directly in the browser of the computer used to display the interface **602**. Thus, the computer **110** may be an inexpensive device such as an embedded computer system, serial server or other device which contains one or more I/O ports. Because an end user might want to view monthly bar graphs **608** of power consumption, Macromedia Flash provides the ability to present real-time moving graphs or pictures. This might be utilized when providing real-time power consumption rate **606** such as a line graph or chart depicting usage over time or up-to-date/cost per billing cycle costs. In addition the interface **602** may provide other data such as peak demand rate including date and time of the peak demand. The interface **602** is structured in automobile-familiar methods for ease of use and so that an end-user need not require special training or skills to use.

In addition, a spreadsheet with web-based query capabilities may also be used to allow users to both view live and historical data and save data to files for later review. Using Microsoft Excel's remote web-query feature will allow the consumer to view all data graphs in real-time while providing a familiar interface means that is available to most any user.

Illustrated in FIG. **7** are devices **702** such as Heating Ventilation Air Condition (HVAC) systems and other power consuming devices that may be connected to the computer **110** through a serial port or Ethernet interface of the computer **110**. The interface **602** may provide the end-user or utility with information on what devices are being currently used, the rate of power consumption, and the ability to control these devices, therefore, allowing the management of the consumption at a local or remote location.

The ability to manage the rate of consumption may be especially advantageous when dealing with utility companies that use a peak-level billing system. Peak-level

billing systems may be implemented as intra-segment pricing systems whereby a peak-use period may have an extremely high rate of power cost and other time segments have a substantially lower power cost. In such systems, consuming power during peak-level periods can have a dramatic effect on the consumer's total power bill. Thus, the computer provides live data and forecast information for both usage (e.g., in kWH) and cost including cost for each time segment and the total of all time segments, allowing the knowledge and control of the amount units consumed and the total cost of that consumption.

By providing a very accurate forecast involving all cost-related segments, the ability for the computer 110 to accurately forecast and signal for reductions or resumptions is significantly increased. If the forecast indicates that usage will exceed the desired amount, the computer may signal for the control of usage of devices to be implemented by manual means or automatically by the computer 110.

Peak-level billing systems may also be used when calculating the forecast total power consumed. In this system, if a customer exceeds a predetermined level of consumption or baseline level, then the utility company may charge a premium rate for the power consumed above the baseline. Some utility companies may also provide rebates on future bills when a customer falls below a predetermined level of usage for a given period. The interface **602** may provide a forecast based on a real-time rate of consumption to determine whether the end-user will be under his monthly baseline utility usage level of consumption or other predetermined level. The forecast may be computed by taking the average consumption used per day of the current billing cycle and multiplying it by the number of days in a billing cycle. So, for example, if the customer of electricity was on day 5 and all segments were equal, the forecast may divide the total power usage at that time by 5 to compute a daily average and then multiply the daily average by the number of days in the billing cycle. A new forecast may be computed continuously based upon present and historical usage. If the forecast indicates that the usage will exceed the baseline level the computer 110 may signal for a home user to manually control the usage of end-use devices directly of from his PDA. For example, the end-user may turn off unnecessary lights, shorten the cycle for dishwashers or clothes washers or decrease the length of time certain devices will run such as a dryer or a

HVAC. Futher, the computer may automatically signal a thermostat or lighting systems, especially in an office setting. Such ability to control allows both the utility and consumer to accurately project both the cost and quantity of use for any specified period and greatly simplifies both the management of the user and the utilities distribution system.

In addition, to avoid being charged a premium rate for consumption, the forecast-driven computer **110** can allow the end user to manually or automatically utilize all of the non-premium utility product allocated to him. For example, rather than shutting off the HVAC system and enduring an uncomfortable climate, the end user can use the forecast to adjust the thermostat (e.g., by preconditioning the computer 110 to adjust the thermostat) to provide additional cooling during non-peak times leading up to a peak period and thus require significantly less cooling during the start of peak times. The thermostat may then also be adjusted to provide lesser cooling during the peak period. It may further allow the user to use energy storage technologies during non-peak times which may then be used off-grid during peak periods.

Using the interface **602** provided by the software stored on the computer **110**, the end-user may also determine an optimization schedule for running the devices **702**. The end-user may obtain data such as cost per hour device used or cost/cycle (washing machine). This may help determine whether the device is properly running as efficient as intended by the manufacturer. Also based on this information, the end-user may program or choose from created device-operating schedules to maximize cost effectiveness and conservation.

In addition to the monitoring and controlling of utility-based consuming devices, the monitoring device **110** may perform other control functions. For example home security systems and fire alarm systems may be connected. The end-user may integrate these devices through the interface and program the monitoring device to respond to signals sent by these systems. For example, if other means of connectivity for a security or fire system were lost, the computer **110** may communicate via an Ethernet interface, the necessary security or fire information as a backup to the primary transmission system. Further, where fire or security systems communicate only via a local display or

enunciator or to a remote monitoring company, the computer **110**, can provide the alerts from the fire or security system directly to a consumer.

Illustrated in FIG. **8**, the computer **110** may be connected to a communication system **804**, such as the Internet. This may allow remote access to the data stored and compiled on the computer **110**. By allowing remote access to the data on the computer **110**, the end-user may control devices from any location such as a computer at work **808** or from his PDA **810**. For example, the end-user may want raise the temperature setting on the thermostat during the hours when he is at work and then remotely lower the temperature of his house before coming home, thus saving significant amounts of electricity use

There may be situations when the end-user wants to make sure that no consumption is taking place, when the end-user is on vacation or business trip, for instance. Remote access to consumption information may provide the end-user with information on whether a particular item is being consumed, at what rate it is being consumed, what device is involved and the ability to control that device.

The utility company **806** may also communicate with the computer **110**. The utility company **806** may download the monthly consumption information from the Internet and bill the end-user accordingly. In addition the utility company **806** may set up an on-line billing service and thus cut down on costs incurred in mailing the bill. Further, the utility company **806** may be alerted by the computer **110** when the forecast shows that consumption is exceeding its forecast allowable demand. The utility company **806** may then send an alerts to households or apartment/office buildings to control the usage during a crisis situation. This alert could be sent via pager, text messaging or other means other means for manual adjustment of consumption. The alert could also be sent for direct control of the consuming devices by the computer **110.** In addition, the consumer and utility could agree for the consumer to install a certain version of the program within the computer that manages consuming devices in a manner agreed upon between the parties in such a way that both parties benefit economically while maintaining the integrity of the end user's environment.

Remote access to the data may provide landlords of apartment/commercial buildings with readily available utility cost information. Landlords can provide potential

lessees current and historic monthly averages of utility bills from their PDA/computer/laptop **814**. Also, landlords may live in locations far from the property they own, possibly in a different state; thus, the landlord may use the data to determine at what rate each tenant is consuming power and directly or, via alert to the consumer, adjust their power use accordingly. Further, landlords may use such information from the computer **110** to automatically adjust or charge for the rent, common area expenses or utility charges accordingly.

By having remote access to control power-consuming devices, the landlord or utility company **806** or, both acting together under contract, might regulate the rate of power consumption while not physically going there. For example, the landlord may control the temperature of the common area of the building from his home computer **814** or even programming the lights to turn off at certain times during the day when sunlight is adequate. The utility company **806** may raise the temperature of thermostats for HVAC systems in summer periods when the power-grid is approaching maximum capacity.

FIG. **9** illustrates an alternative embodiment of the present invention. Unless specifically stated, all elements, of FIG. **9** have a one-to-one functional correspondence with those of FIG. **1**. FIG. **9** differs from FIG. **1** in that the serial cable **120** (from FIG. **1**) that connects the reader **104** and the data-collection unit **106** is replaced with a wireless communication channel. A transmitter **906** for sending wireless communications may be attached to the reader **104** using a shorter serial cable. A receiver **908** may be attached via another shorter serial cable to the data-collection unit **106** for accepting the transmitted communications from the transmitter **906**. The transmitter **906** may send data via a wireless carrier frequency, such as 433 MHz, which is standard for garage door openers. It will be apparent, however that another frequency (e.g., 900 MHz) could be used. The signals sent via the transmitter **906,** may be in the format of pulses that are created directly from the intervals of lower levels of reflected light sensed by the sensor **210**. Thus, each pulse formed by the reader may result in a pulse at the carrier frequency communicated by the transmitter **906**. To communicate the pulse to the data-collection unit **106**, the transmitter **906** may send a burst of the carrier frequency to represent each revolution of the rotating disk **502**. The wireless signal from the transmitter **906** may be

encoded with identification information placed on the carrier frequency to prevent interference from other sources. It will be apparent that a number of different schemes may be used for communicating the revolution of the rotating disk **502** via the transmitter **906** and receiver **908**. The transmitter **906** and the receiver **908** may receive operating power from a battery or a wall-mounted AC to DC converter.

Similarly to the embodiment of FIG. 1, the reader **104** may communicate directly with the computer **110**. In which case, the receiver and cable **904** may be mounted to the computer **110** rather than the data collection unit **106**. In addition, the data collection unit **106** may be omitted.

Wireless communication may be used to help eliminate routing problems when using serial cables such as length of the cable needed and outdoor to indoor routing. The wireless communication device would also be helpful for small businesses in which there are multiple readers which all have to be connected to a monitoring device **110**.

While the foregoing has been with reference to particular embodiments of the invention, it will be appreciated by those skilled in the art that changes in these embodiments may be made without departing from the principles and spirit of the invention, the scope of which is defined by the appended claims.